

DOE/OE Transmission Reliability Program

Advanced Applications R&D DOE/NIST Collaboration

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Project Team

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CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

ORNL CERTS Task Transition

FY14 AOP Tasks

- NASPI Support (King)
- Advanced Applications R&D (Buckner)
 - Collaboration with NIST and PNNL
 - Technology Assessment for Next-Gen PMUs
 - NIST Round Robin
 - Support Measurement Needs; including IEEE 1588
 - Field Characterization of Machine Parameters Automated Learning System
 - Impacts on Synchrophasor-based Applications
- Load as a Resource (LAAR) Demo (Starke)
- FOA 767 Support (Smith)
- Powerline Conductor Accelerated Testing (PCAT) (Irminger)

FY15 AOP Tasks

- NASPI Support (King)
- Advanced Applications R&D
 - Collaboration with NIST and PNNL (including IEEE 1588) (Ewing)
 - Continuous Data Driven Model Development Framework (Buckner)
 - Impacts on Synchrophasor-based Applications (Liu)
- Load as a Resource (LAAR) Demo (Shipley)
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Project Objective

- **Background** – Industry dependence on PMUs is expected worldwide as their use increases
 - More than 20 PMU manufacturers
 - More than 50 different models of PMU
 - Recognition that conformance and metrology R&D are necessary elements for widespread industry acceptance
- **Objective** – Seek out opportunities for advanced applications R&D collaborations between DOE and NIST
 - Coordinate regular discussions between DOE labs and NIST
 - Support the ability of independent test labs to verify PMU compliance with IEEE C37.118.1
 - Identify pressing issues facing PMU users
 - Ensure the quality of future PMU-related instrumentation developments



Collaboration between NIST, ORNL, and PNNL

- Continuation of coordination discussions between NIST, ORNL, and PNNL regarding research activities
- Supporting PMU compliance
- Identifying pressing issues and new areas for collaboration – based on “Top 3” areas of interest for each organization
- Planning “Next Generation Power Grid Instrumentation Workshop”

Interagency Agreement

DOE Support for Synchro metrology

Research Proposal

Physical Measurement Laboratory / Quantum Measurement Division
October 31, 2012

I. Objective: To support the ability of independent test labs to verify PMU model compliance with IEEE C37.118.1

A. Test lab round robin

1. Technical Problem

The round robin is a first look at external test lab ability to perform tests required by C37.118.1 and a comparison of test results between various labs and NIST. While the round robin does not assess a test lab's capability to certify PMU compliance, it will lead to greater confidence and resolution of testing differences due to varied interpretations of the standard.

2. Statement of Work

- Revise Charter and re-send to participants
- Create results Excel spreadsheet for reporting the test results
- Perform preliminary DUT testing at NIST synchro metrology lab
- Conduct round-robin with participant labs
- Perform data analysis
- Report the results and findings concerning the capability of participating labs

3. Timeframe

- Starting date: Early 2013
- Target completion date: December, 2013

II. Objective: Identify pressing issues facing PMU users

A. Time synchronization redundancy

1. Technical Problem

Vulnerabilities in the GPS and other Global Navigation Satellite Systems is of great concern to not just the power industry, but also the communications and aviation industries. In electrical power, redundancy is required to ensure reliability. GPS is designed and operated by the Department of Defense, it is co-funded by DOE and Department of Transportation, yet the Federal Communications Commission and the DOE are key stakeholders. Time synchronization redundancy is a discussion for all of these stakeholders together and not just one of them. NIST/DOE must reach out to each of these departments and start the discussion or join in if it is already in progress without us and ensure that the issues relevant to the power industry are addressed. No one department will do it alone.

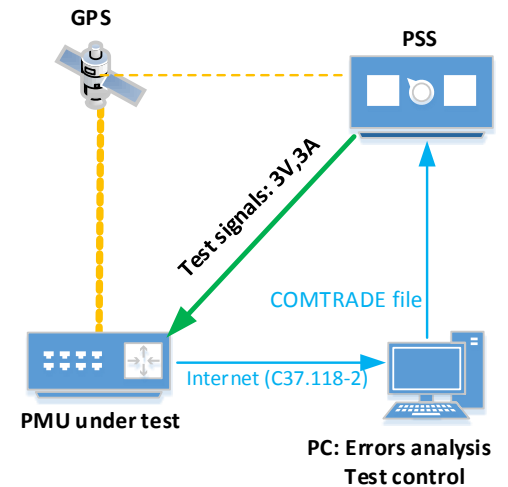
2. Statement of work

- Explore / analyze issues / vulnerabilities with GPS and GNSS with relevant stakeholders including FCC, FAA, and the power, transportation, and communications industries



Supporting PMU Compliance

- Completed participation in NIST PMU round robin testing
- Testing intended to provide verification of measurement capabilities of participating laboratories and to ensure the uniformity of the PMU calibration
- Ran over 600 tests (multiple configurations)
- Comparison with NIST data was close, leading to a good result
- Developed compensation/calibration method that greatly improved the performance of the PMU testing system



Spotting Pressing Issues–“Top 3” Areas of Interest

- **NIST**
 - Performance of merging units
 - Performance for applications that use PMUs
 - Timing redundancy
- **PNNL**
 - Distribution-side PMUs
 - What’s to be served by understanding PMU errors during switching transients?
 - On-line component condition monitoring
- **ORNL**
 - Timing redundancy
 - Performance for applications that use PMUs
 - Instrumentation for distribution systems



Next-Generation Instrumentation Workshop

- Location: Oak Ridge/Knoxville, TN
- Tentative Date: October 27-28, 2015
- Chair: Yilu Liu, ORNL/UTK
- Logistics: Paul Ewing/help from NIST
- Attendance: Invitation only
- Potential agenda topics (sample)
 - Digital PMUs/sample value PMUs
 - Merging units and beyond
 - Requirements for distribution side vs transmission side
 - Measurement issues (data rates, delays, latency, limits, etc.)
 - Utilities' perspective
 - Impact of renewables



Participation in Timing Activities

- IEEE P1588 Working Group – updating Precision Timing Protocol (PTP) for applications requiring sub-nanosecond timing
- Time Aware Applications, Computers, and Communication Systems (TAACCS) Group – collection of individuals and organizations interested in addressing unique problems surrounding distributed timing
- Cyber-Physical Systems (CPS) Public Working Group, Timing Section – developing framework for correct timing by construction to allow large scale growth



IEEE P1588 Working Group

- **Charter** – Issue new edition of IEEE 1588-2008, *Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems*
- **Organization** – PAR approved on June 14, 2013
- **DOE Lab Role** – Actively participating in working group
 - Sitting in on Architecture, High Accuracy, Security, Management, and Upkeep subcommittee telecons
 - Preparing document outlining how IEEE 1588 can operate in an environment where security is a concern
 - Hosting Fall meeting in Knoxville, TN



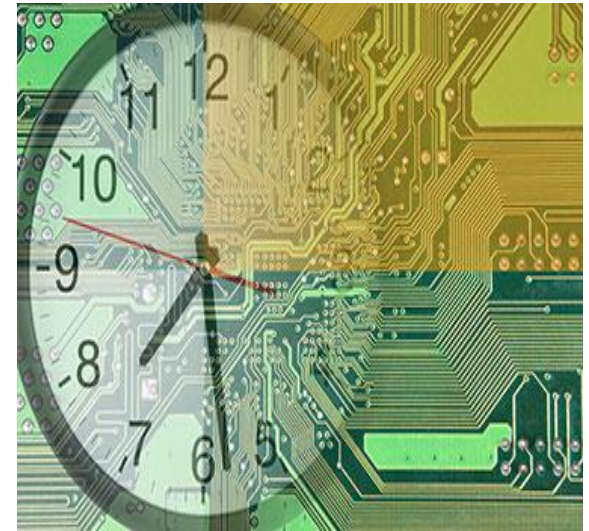
TAACS Group

- **Charter** – Collection of people from academia, industry, and research labs interested in the unique problems surrounding distributed clock agreement
- **Organization** – Led by Carnegie Mellon University and NIST; 2nd meeting held in Mountain View, CA in March 2015
- **DOE Lab Role** – Participated in writing white paper outlining the need for timing research and proposal for NSF support for TAACS



CPS Public Working Group – Timing Section

- **Charter** – Establishing the operational framework element for large scale interaction between cyber-physical systems for timing correction by construction
- **Organization** – Led by NIST; participants include government, academia, and industry; recent meeting in April 2015
- **DOE Lab Role** – Participating in review of draft Framework Element report



Deliverables and Schedule

- **Collaboration between NIST, ORNL, and PNNL**
 - Participation in scheduled discussions on collaborative activities and distribution of minutes - at least quarterly
- **Next Generation Power Grid Instrumentation Workshop**
 - Technical report on findings from “Next Generation Power Grid Instrumentation Workshop” – December 2015
- **PMU Compliance**
 - NIST round robin test results provided to NIST – complete
- **Timing Activities**
 - Meeting participation and technical input to working group documents – ongoing updates



Risk Factors

Risk factors affecting the timely completion of planned activities, as well as movement through the RD&D cycle

There are no foreseen technical, fiscal, logistical, or organizational risk factors



Follow-on Work

Early thoughts on follow-on work that should be considered for funding in FY16

- Continuing support of PMU compliance activities
- Hosting and documenting results from “Next Generation Power Grid Instrumentation Workshop”
- Expanding collaboration efforts
- Continuing coordination meetings



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ORNL CERTS Task Transition

Backup Slides



ORNL CERTS Task Transition

FY13 AOP Tasks

- NASPI Support (Rizy)
- Advanced Synchrophasor Metrology (Snyder)
 - Review NIST Technical Plan
 - NIST Round Robin
 - Guide for Installation of Multi-function PMUs
 - Support IEEE 1588
 - In-situ Calibration of Field-Installed PMUs
 - Impacts on Synchrophasor-based Applications
 - GPS Spoofing (ORNL LDRD)
 - Real-time Model Calculation/Validation
- Frequency Response of Load Assessment (Snyder)
- Technology Assessment for Next-Gen PMUs (Buckner)
- GPS Issue Management (Young)
- LAAR Demo (Starke)



ORNL CERTS Task Transition

FY14 AOP Tasks (redlined)

Red – discontinued
Green - new

- NASPI Support (~~Rizy~~ King)
- Advanced ~~Synchrophasor Metrology~~ Applications R&D (~~Snyder~~ Buckner) [new title based on guidance from LBNL]
 - Collaboration with NIST and PNNL ~~Review NIST Technical Plan~~
 - Technology Assessment for Next-Gen PMUs [moved from top-level to sub-level; aligned w/ NIST/PNNL work]
 - NIST Round Robin
 - ~~Guide for Installation of Multi-function PMUs~~ [work ended in FY13]
 - Support ~~Measurement Needs~~; including IEEE 1588
 - ~~In-situ Calibration of Field-Installed PMUs~~ Field Characterization of Machine Parameters Automated Learning System [morphed from calibrating PMUs to characterizing machine parameters]
 - ~~Real-time Model Calculation/Validation~~ [subsumed into automated learning system above]
 - Impacts on Synchrophasor-based Applications
 - ~~GPS Spoofing ORNL LDRD~~ [work ended in FY13]
- LAAR Demo (Starke)
- ~~Frequency Response of Load Assessment (Snyder)~~ [work ended in FY13]
- FOA 767 Support (Smith) [new work]
- PCAT (Irminger) [continuation of existing work; new to CERTS]
- ~~Technology Assessment for Next-Gen PMUs (Buckner)~~ [moved to sub-level]
- ~~GPS Issue Management (Young)~~ [work ended in FY13]



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- Advanced Applications R&D (~~Buckner~~)
 - Collaboration with NIST and PNNL (~~Ewing~~)
 - ~~Technology Assessment for Next-Gen PMUs~~ [subsumed into NIST/PNNL collaboration project above]
 - ~~NIST Round Robin~~ [completed in FY14]
 - Support Measurement Needs; including IEEE 1588
 - ~~Field Characterization of Machine Parameters Automated Learning System~~ Continuous Data Driven Model Development Framework (Buckner) (retitled to better reflect the focus of the analysis framework)
 - Impacts on Synchrophasor-based Applications (Liu)
- LAAR Demo (~~Starke~~ Shipley)
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